UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
166 Water Street
Woods Hole, MA 02543

November 15, 2003 DRAFT

CRUISE RESULTS

NOAA Fisheries Research Vessel DELAWARE II
Cruise DE 03-08 (Parts 1 – 3)

Atlantic Herring Hydroacoustic Survey

CRUISE PERIOD AND AREA

Cruise operations were completed on the continental shelf (depths to 350 m) in the Gulf of Maine and northern Georges Bank regions, including the Canadian Exclusive Economic Zone on eastern Georges Bank. The 2003 Fall Atlantic Herring Hydroacoustic Survey was conducted during three parts between 2 September and 10 October 2003. Acoustic calibrations were completed during the first day of Part 1 at the Woods Hole Oceanographic Institute's pier and in Cape Cod Bay. After completing the calibrations, the RV Delaware II conducted surveys along northern Georges Bank during 4-12 September (Fig. 1). Part two was dedicated to repeating the Georges Bank survey during 17-27 September (Fig. 2). Survey operations for Part 3 occurred in the Jeffreys Ledge and northern Georges Bank regions during 30 September - 11 October (Fig. 3).

OBJECTIVES

The Northeast Fisheries Science Center (NEFSC) conducts annual Atlantic Herring Hydroacoustic Surveys each autumn on the predominant historical spawning grounds of Atlantic herring (*Clupea harengus*) in the Georges Bank and Gulf of Maine regions. The main goal of this cruise was to provide more cost-effective, timely, and accurate fisheries-independent estimates of herring spawning stock biomass using state-of-the-art technologies. Operational objectives of this cruise were to (1) calibrate the EK500 scientific echosounder, (2) conduct acoustic surveys of Atlantic herring (*Clupea harengus*) in the Georges Bank and Gulf of Maine regions, (3) collect biological samples and verify species-specific backscatter measurements with midwater trawl and underwater video deployments, and (4) conduct *in-situ* multifrequency target strength (TS) experiments on herring.

METHODS

EK500 Calibrations: Before conducting fisheries acoustic survey operations, the EK500 Scientific Echo sounder was calibrated by the standard calibration sphere method. A calibration sphere of known target strength was suspended under the hull-mounted transducers (split-beam 18, 38, and 120 kHz) of the EK500 system. Simrad copper spheres with 63, 60, and 23 mm diameters were used for the 18, 38, and 120 kHz frequencies, respectively. Each calibration sphere was moved throughout the acoustic beam pattern using three remotely controlled downriggers. The TS gain for each split-beam transducer was derived using the Simrad Lobe program (v.95.01.17). Sv gain was verified based on the EK500 integration tables. Existing survey parameters for the transducers remained unchanged given the high precision and agreement with previous calibration results. Ambient noise tests were conducted to ensure no cross-interference between acoustical instrumentation. The amplitude measurement from the EK500 transceiver test menu was checked routinely before, during, and after each cruise to ensure the EK500 system was operating properly during survey operations.

Survey design: Systematic surveys were conducted on the primary historical spawning grounds of Atlantic herring in the Georges Bank and Gulf of Maine regions. The survey design included a series of evenly spaced (10 nmi separation) parallel transects, the first of which was randomly selected. A transect is defined as a portion of the cruise track with a constant vessel heading and speed, and was assigned a unique sequential number. Survey speeds ranged from 8-11 knots depending on weather conditions. Acoustic data from the 18, 38, and 120 kHz frequencies were collected simultaneously along the cruise track and during gear deployments using the EK500 Scientific Echosounder. Deployments using midwater trawl, underwater video, and CTD (conductivity-temperature-depth) gears were routinely conducted to identify species composition of backscattering aggregations, collect biological data, and document hydrographic conditions. Trawl catch, navigational, oceanographic, event-logging, and meteorological data were recorded using the RV Delaware's onboard Fisheries Scientific Computer System (FSCS).

Experimental research: EK500 operations were conducted along experimental transects in the northern Georges Bank and Gulf of Maine regions during Part 1 for volume backscatter and individual target strength (TS) measurements on Atlantic herring. Experimental transects were repeated during day, twilight, and night periods to investigate the diurnal variability in acoustic measurements. Midwater trawling, underwater video, and CTD were also conducted during the experiments.

EK500 Scientific Echosounder: A Simrad EK500 Scientific Sounder System (v.5.30) was the primary instrumentation used during this cruise, as well as during the previous 1998-2002 Atlantic Herring Hydroacoustic Surveys, to obtain acoustic measurements for estimating fish biomass and abundance. The EK500 provides low self-noise, high transmit power, instantaneous dynamic range of

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160 dB, unlimited range compensation (TVG), and efficient transducers for scientific-grade detection capabilities for fisheries research and assessment. The RV Delaware's EK500 operated three hull-mounted transducers (split-beam 18, 38, and 120 kHz) continuously along transects and during gear deployments. EK500 data were collected simultaneously from each of the three frequencies throughout the cruise at a ping rate of every two seconds. An operational event log was maintained throughout the cruise using the vessel's Scientific Computer System's (SCS) event log program and log sheets.

EK500 Data Collection and Post-Processing: EK500 data were logged to the vessel's PC server using SonarData's EchoLog program (v.2.25.15) via TCP/IP ETHERNET line. These data were vertically echo-integrated into volume backscatter estimates (Sv in units of m^2/m^3) by 1.0 m depth increments.

Volume backscatter measurements were converted to areal backscatter (Sa in units of m^2/nmi^2) as a relative index of abundance along the cruise track. Individual target strength (TS) measurements were also collected by the EK500. The EK500 received its navigational input from the vessel's Scientific Computer System (SCS) differential GPS output. Preliminary post-processing of the EK500 data was conducted at sea using Echoview software (v.3) to filter unwanted noise and partition species-specific backscatter. Data for all three frequencies were post-processed and apportioned to herring backscatter while at sea based on midwater trawl catches, target strength distributions, and backscattering patterns of aggregations. The 38 kHz data are the primary data used for deriving population estimates, and the 18 and 120 kHz data were post-processed identically for multifrequency analyses. After post-processing the data at sea, the EK500 data were downloaded to a shore-based computer at NEFSC for archiving upon the completion of each cruise part. These data will be further processed at the laboratory and loaded into the NEFSC Oracle database system.

High Speed Midwater Rope Trawl (HSMRT): The High Speed Midwater Rope Trawl (HSMRT, Gourock design R2028825A) was deployed intermittently to sample acoustic backscatter to verify species composition and collect biological samples. The HSMRT was towed at an average speed of 4.5 knots typically for 30 minutes in duration. However, tow duration often varied depending on acoustical fish signals observed by the trawl monitoring system. Tow duration was defined as the time between setting the doors and when doors were hauled out of the water. The tow profile of the trawl was usually dropped incrementally through the water column to the desired depth of the scattering layer or about 10 m off the bottom, held at that depth for the remaining duration depending on the fish targets observed, and then retrieved. The HSMRT is a four seam pelagic trawl designed with symmetrical headrope, footrope, and breastlines of 53.1 m length. The HSMRT was rigged to 1.8 m^2 double-foiled Suberkrub-type doors with 62.4

m of upper and lower bridles/legs. The optimum tow configuration (2.5 m setback, 273 kg tomweights, intermediate door spread with two shoe weights per door) was implemented during survey operations. The mouth opening of the HSMRT was approximately 13 ± 3 m vertical and 27 ± 5 m horizontal. The objectives of the midwater trawl operations were to obtain biological samples and verify biological composition of the acoustic backscatter. Therefore, the trawl were targeted on selected backscatter layers and trawl catch data should not be used for abundance estimates.

Midwater Trawl Performance Monitoring: Trawl performance was measured with a FS903 system, ITI system, and a pair of Vemco temperature-depth Minilog sensors. The Simrad FS903 Trawl Monitoring System is a third-wire device that provided real-time sonar images of the trawl mouth-opening. The FS903's sonar also displayed fish in and around the trawl opening, allowing approximate determination of the number of fish for scientific samples. The Simrad ITI wireless trawl sensors were used to obtain point measurements of the trawl depth, wing spread, and door spread. Minilog depth-temperature probes were attached to the trawl headrope and footrope to provide continuous depth-temperature and trawl performance profile data for each deployment. The Delaware's trawl wires were calibrated before the cruise departed.

Biological Sampling: The catch from each midwater trawl was sorted, weighed, and measured (fork length to the nearest cm) by species according to standard NEFSC procedures. Additional biological sampling for Atlantic herring included individual weights (to nearest 0.1 g), fork lengths (nearest mm), volumetric stomach content analyses, and otolith samples for aging. Trawl station, catch, and biological data were entered using the Delaware's onboard Fisheries Scientific Computer System (FSCS) entry system.

Static Underwater Stereo Video: Static underwater stereo video deployments were deployed intermittently during the cruise to directly verify acoustic targets within the acoustic beam. The video system was deployed midship from the forward A-frame alongside the acoustic beam of the EK500 while the RV Delaware drifted over selected backscatter aggregations. The video tow-body had a tail-fin which typically oriented the video cameras toward the beams of the vessel's EK500 transducers. A pair of matched underwater CCD video cameras (DSP&L Super SeaCam SSC-T5000-B-E) were mounted to obtain stereo imagery of targets. The video cameras have a titanium housing rated for 6,000 m. The cameras are equipped with a CCD sensor providing low light sensitivity of 0.001 lux @ f0.80. Two DSP&L Multi-SeaLites provided illumination that could be dimmed remotely using a 120v voltage regulator. The SeaLites were fitted with filter adaptor cowls and red light filters were used during the cruise to minimize fish avoidance. Real-time dual video and environmental data were recorded from the video system through 300 m multiconductor cable to a PC computer and digital tape recorders. Each video frame was time-stamped with a time-code generator for synchronization of stereo imagery. Real-time depth profile, temperature, compass bearing, and three-dimensional orientation

of the camera system were recorded every second from the underwater JASCO Attitude Sensor. JASCO data recorded by the PC workstation were time-stamped from the PC's internal clock which was synchronized to the vessel's master GPS clock using Dimension-4 software.

Fisheries Scientific Computer System (FSCS): The RV Delaware's Scientific Computer System (SCS) continuously collected navigational, oceanographic, and meteorological data throughout the cruise track. The Delaware's SCS was upgraded last year to the Fisheries Scientific Computer System (FSCS) which included the onboard data entry from the trawl catch processing. Trawl catch and biological data are entered on deck using Windows touch screen menu systems, digitized measuring boards, and electronic scales. The FSCS Event Logger program was also utilized during the cruise to develop a detailed Event log file with the start and end points of times and positions for each transect and deployment. The Event log also contained operational and observational comments to optimize data management and accessibility of the acoustical data. All computers involved with data collection were synchronized to the Delaware's master clock.

Other Data: Conductivity-temperature-depth (CTD) casts were conducted at the transect nodes and gear deployment locations. Vemco Minilog temperature-depth probes were attached to all gear deployments, included selected CTD casts, to obtain additional temperature and depth profile data.

RESULTS

Part 1: The RV Delaware II departed the Northeast Fisheries Science Center at Woods Hole, Masssachusetts on 2 September at 15:00 GMT (all times herein are in Greenwich Median Time which is an additional 4 hours to eastern local time), and docked at the Woods Hole Oceanographic Institute's pier to conduct EK500 calibrations. The EK500's 120 and 38 kHz split-beam transducers were accurately calibrated using the standard calibration method. Transceiver gain settings were modified by less than 0.15 dB from previous surveys. The RV Delaware departed Woods Hole on 3 September at 14:00, and arrived in Cape Cod Bay that evening to calibrate the EK500's 18 kHz transducer. The 18 kHz calibration was partially completed due to the loss of the calibration sphere on fixed gear while drifting. The RV Delaware departed Cape Cod Bay during the morning of 3 September, and arrived on the Northeast Peak of Georges Bank during 4 September at 02:12 to begin the survey operations. The survey along northern Georges Bank was conducted between 4 September at 02:12 and 10 September at 06:28. The remaining time during 10 September at 12:10 through 11 September at 13:43 to allocated to in-situ measurements using the underwater video system with an attached 38 kHz transducer. The RV Delaware arrived in Woods Hole on 12 September at 11:00. Approximately 1,490 nautical miles of transects and 67 deployments (9 midwater trawls, 51 CTD casts, 6 underwater video, and one underwater video/transducer) were completed during Part 1. The constant tension of the third-wire winch for the FS903 trawl monitoring system malfunctioned

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repeatedly resulting in four aborted trawl deployments. During one of the aborted deployments, the constant tension was worked on for several hours while the slack third-wire wrapped around the starboard door causing severe damage to the midwater trawl. Approximately 400 m of third-wire was cut and the remaining 600 m of wire remaining on the wire-third winch limited our midwater trawl capabilities to no more than 200 m sampling depth. This also left us with only one midwater trawl with no backup net. Few herring were observed in the survey area with the acoustic echograms, midwater trawl, and underwater video deployments during Part 1.

Part 2: The RV Delaware departure from Woods Hole was delayed two days due to the repair of the constant tension on the third-wire winch. The RV Delaware departed Woods Hole during the afternoon of 17 September, and began survey operations on the western Georges Bank on 18 September at 04:10. The RV Delaware stopped survey operations on 18 September at 12:50 to escape the increasingly rough weather sea state from the approaching hurricane Isabel, and headed to the Northeast Peak to continue with the Georges Bank survey. The survey resumed in the northeastern portion of Georges Bank on 19 September at 07:07. The Georges Bank survey was completed on 24 September at 18:55, and further acoustic measurements were not made due to the lack of herring in the area. Approximately 1,425 nautical miles of transects and 61 deployments (9 midwater trawls, 45 CTD, 9 video, 4 video/TS) were completed during the second Georges Bank survey. Few herring were observed during this survey. Therefore, the RV Delaware headed to Cape Cod Bay, and the EK500's 38 and 120 kHz transducers were re-calibrated during 25 September from 02:34 through 09:50. Calibrations once again confirmed the EK500 system was working properly and the transceiver settings were accurate. The RV Delaware arrived in Woods Hole a day early on 25 September at 18:00.

Part 3:
The Delaware departed Woods Hole on 29 September at 18:00, and began survey operations on southern Jeffreys Ledge on 29 September at 23:43. The Jeffreys Ledge survey was stopped on 1 October at 01:05 to conduct inter-vessel acoustic calibrations with the FV Adventurer. The FV Adventurer was contracted by the Gulf of Maine Research Institute to conduct cooperative herring acoustic surveys along coastal Maine. The RV Delaware followed the FV Adventurer in an effort to locate aggregations of herring. With the assistance of the RV Delaware’s omni-directional sonar, the FV Adventurer was unable to find enough herring on Jeffreys Ledge and decided to move inshore off Portland, Maine where herring were reported. The FV Adventurer located herring and established transects for the inter-vessel comparison, unfortunately the RV Delaware was unable to maneuver safely due to shallow inshore waters (depths less than 4 m) and heavy traffic. Therefore, the RV Delaware broke-off operations with the FV Adventurer to complete the Jeffreys Ledge survey. The

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Jeffreys Ledge survey was completed on 2 October at 07:37, and the RV Delaware headed to the Northeast Peak to begin the Georges Bank survey. Few herring were observed on Jeffreys Ledge. The Georges Bank survey began on 3 October at 00:22. The RV Delaware jogged during the 3 October 07:40-16:56 and 5 October 07:58-10:18 periods due to rough weather. Survey operations also stopped during the 4 October 13:07-21:09 period when a midwater door was replace due to a bar breaking at a rusted weld (where the safety chain is attached). The Georges Bank survey was completed on 10 October at 03:00. Approximately 2,800 nautical miles of transects and sixty-eight deployments (9 midwater trawls, 50 CTD, 2 video, 5 video/TS, and 2 insitu-TS while drifting) were completed during Part 3. The Delaware arrived in Woods Hole on 10 October at 06:00.

In summary, the Fall 2003 Atlantic Herring Hydroacoustic Survey successfully completed the primary objectives. Approximately 5,100 nautical miles of acoustic transects were completed in the Gulf of Maine and Georges Bank regions. Preliminary abundance estimates indicate a large biomass of herring were present along northern Georges Bank throughout the cruise period, while a relatively low biomass of herring were observed in the Jeffreys Ledge region. The predominant pelagic fish captured was Atlantic herring, particularly in the northern Georges Bank region. A total of 198 gear deployments were conducted throughout the cruise, with 147 CTD, 27 midwater trawl, 20 video , and 4 other deployments.

DISPOSITION OF DATA

All data and results are archived at the Northeast Fisheries Science Center. Results will be presented and data distributed on CD-ROM at an annual Northwest Atlantic Herring Acoustic Workshop in conjunction with scientists from the Canadian Department of Fisheries and Oceans.

SCIENTIFIC PERSONNEL

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Part 1 September 2 - 12, 2003
Part 2 September 15 - 26, 2003
Part 3 September 29 - October 10, 2003

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